DOCUMENT RESUME

ED 312 399 CE 053 470

TITLE	Electronic Computer Aided Design. Its Application in FE.
INSTITUTION	Further Education Unit, London (England).
REPORT NO	ISBN-1-85338-152-7
PUB DATE	Aug 89
NOTE	7p.
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Computer Assisted Instruction; Continuing Education; Courseware; *Curriculum Development; *Electricity; *Electronics; Feasibility Studies; Foreign Countries; Higher Education; Staff Development
IDENTIFIERS	*Computer Assisted Design; United Kingdom

ABSTRACT

A study was conducted at the Electronics Industrial Unit at the Dorset Institute of Higher Education to investigate the feasibility of incorporating computer-aided design (CAD) in electrical and electronic courses. The aim was to investigate the application of CAD to electrical and electronic systems; the extent to which industrial developments are reflected in further and higher education courses; the extent to which curricular changes are necessary; and the extent of resource and staff development implications. The research was undertaken by means of a survey and analysis of electronic CAD (ECAD) software and its suitability, or adaptability, for student use; a survey of the use of ECAD by 43 colleges (mainly) in southwest England, with a 70% response rate; a conference of college staff and representatives of ECAD software suppliers; and visits to colleges and industry. Results of the survey, conference, and visits clearly indicated a need for a development plan for the introduction of ECAD into further and higher education courses. The problem of familiarization time and availability of appropriate software, together with the time taken to generate good teaching support material, were noted and possible solutions outlined. Specific recommendations were made for alleviating the high cost of software; establishing national and regional advice centers to provide support for the production of ECAD hardware/software and training courses for staff; selecting courses and material based on a CAD approach; and initiating a program of regular awareness seminars to keep colleagues aware of activity in this field of study. The study proved valuable both as an information-gathering exercise and a means of highlighting some potential problems that could have a deleterious effect on the efficiency and viability of the United Kingdom's electronics industry. (NLL)

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This bulletin summarises a project (RP453) investigating the feasibility of incorporating computer aided design in electrical and electronic courses. The project was carried out by Jim Roach and Sa'ad Medhat at the Electronics Industrial Unit at the Dorset Institute of Higher Education.

The aim was to investigate:

- *the application of CAD to electrical and electronic systems;*
- *the extent:*
  - *to which industrial developments are reflected in further and higher education courses,*
  - *to which curricular changes are necessary,*
  - *of resource and staff development implications.*

The research was undertaken by means of a survey and analysis of ECAD software and its suitability, or adaptability, for student use; a survey of the use of ECAD by colleges (mainly) in south-west England; a conference of college staff and representatives of ECAD software suppliers; and visits to colleges and industry.

An overall strategy is required if good practice in ECAD is to be disseminated widely in the further and higher education system. This should include a programme of awareness-raising seminars, bulk purchases and use of site licences for software, regional advice centres, and the generation of ECAD material suitable for use in education and training.

Electronic Computer Aided Design Its application in FE

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Background

Modern complex electronic products require a large amount of new design and testing skills to be realised. One way of achieving a cost-effective solution is to use computer simulation and modelling techniques. Industry is rapidly applying such methods to assist the design and implementation of electronic systems. After a relatively slow start, electronics firms in the UK have recognised the importance of Electronic Computer Aided Design (ECAD) as a major new design development facility. Organisations that put their manpower effort into an integrated design system have been rewarded by achieving, for example, a reduction in lead time of over 50%, better production control and lower modification costs.

To summarise, some of the advantages of using ECAD are that:

- quick alterations can be made by the engineer when and where refinement is needed, or errors located and corrected;

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August 1989

- only one design cycle is needed to get a design right the first time;
- better documentation means an earlier start to production.

So what is the educational sector doing about ECAD? ECAD has made a considerable impact in the university/polytechnic sector at degree/HND level. A University Grants Commission (UGC)/ Department of Trade and Industry (DTI) initiative made a significant capital sum available for the purchase of professional software for integrated circuit design, with licences for unlimited use in teaching and research. However, with the exception of simple simulation and printed circuit board (PCB) design packages, few further education colleges appear to include ECAD techniques in their teaching programme, although the tools and techniques of implementing designs are becoming more widely available. This is because industrial software is often unsuitable for teaching purposes and professional software with the appropriate hardware is expensive. It was therefore decided to investigate the use of computers in the teaching of electrical and electronic subjects across the further education curriculum.

Aims

To investigate:

- the application of CAD to electrical and electronic systems (ECAD);
- the extent to which industrial developments are reflected in further and higher education courses;
- the curricular changes necessary to ensure that industrial needs are met;
- the consequential resource and staff development implications.

Method

Each area of the electrical/electronic curriculum was analysed with a view to identifying areas where the use of CAD or information technology would assist the learning process, followed by a survey of the extent to which the computer-based design aids were used to teach electrical/electronic engineering in FHE. The survey involved contacting all colleges in the area covered by the Southern Regional Council for Further Education, and visiting institutions which claimed a significant level of activity in the use of ECAD in this area of the curriculum. In the light of feedback and discussions arising from initial returns of the survey, a conference/workshop was held for further education lecturers involved in teaching electronics. Experienced users of ECAD shared experiences, and software suppliers demonstrated appropriate packages.

The following list indicates areas in which the use of computers could assist learning in electrical/ electronics courses:

General area	Specific subject area
Principles/Science	Mathematics Circuit Theory Semiconductor Physics Instrumentation
Applications/Technology	Digital Electronics Analogue Electronics Microelectronic Systems Microprocessors Microelectronic Technology VLSI Systems Production Electronics Software Design and Programming Languages Telecommunications Datacommunications Testing Methods and Fault Finding Control Systems
Project Work	Individual project Group project Integrative assignments
Common Skills	Report writing Presentation skills
Industrial Studies	Economics and Finance Management

Survey

The questionnaires were sent to a total of 43 colleges, with a return ratio of nearly 70%. This is regarded as indicative of the interest shown in the subject.

Synopsis

The overall picture which emerges from the findings of the survey is that practically every college engaged in the teaching of Electrical or Electronic Engineering is involved in using computers and CAD techniques, but there is great variety in the level of involvement and the extent of use. Most of the colleges use word processing packages. Colleges using PCB layout packages, circuit simulation, semi-custom techniques and fault simulation are in a minority, which seems to reflect the industrial picture.

Most of the packages used are produced commercially and hardware platforms are consistently either BBC or IBM PC based. Resources are, in the main, based in departments. Staff training is internal, with self-learning the predominant mode. Staff reacted enthusiastically, but the time needed for implementation is a potential problem as programs become more sophisticated and capable of more complex tasks. The preferred mode of delivery is via introductory lectures and extensive 'hands on' experience based on project work.

The major problems are lack of resources and the long familiarisation times needed. Student reaction was encouraging, 68% being enthusiastic.

Relevant information is usually obtained from technical journals and exhibitions; colleges generally pursue the subject further and wider, despite limited funding. Of the respondents, 81% see the provision of a regional centre for hardware/software demonstration and training as very desirable and would use such a resource.

The main areas of CAD development are in PCB, analogue and digital simulation, with semi-custom design being of less immediate interest.

Industry has expressed an interest in CAD, but not by any means unanimously (70% to 30%).

ECAD conference at Dorset Institute

The colleges originally approached were sent details of the conference plus an invitation to make a presentation. Thirty delegates from 17 colleges attended, with presentations from Dorset Institute and five other colleges. Topics covered included user experiences with CAD for electrical contracting, PCB design, analogue circuit design, digital circuit design and semi-custom design. Other subjects discussed related to relevant resource and managerial issues arising from adopting CAD techniques. A brief synopsis of each presentation, together with the conclusions and recommendations, follows.

Introduction and welcome

The aims and objectives of the project were outlined, together with the conference programme.

ECAD, the electronics laboratory of the future

J Roach, Dorset Institute

This presentation included an outline of the electronics business, the benefits of CAD and why industry must adopt the approach to survive. As designs become more complex and timescales become compressed, the idea of a soldering iron and a handful of chips is replaced by a sophisticated workstation with a high level of design and simulation software. USA and Japan are rapidly taking up ECAD. If the UK electronics business is to remain competitive, the onus rests on educational establishments in partnership with industry to train engineers to use ECAD – the future electronics laboratory.

User experience of ECA-2 for circuit theory

J Sanderson & A Robinson, Dorset Institute

ECA-2 is an analogue circuit simulation to run on an IBM PC compatible. Circuit theory is traditionally regarded as a rather dry subject with low student interest. Thus student performance is poor relative to other subjects. In an attempt to rectify this, ECA-2 software was used instead of traditional laboratories. Students were able to build and experiment with circuits after a relatively short familiarisation time. It was felt that student interest and motivation at HNC level was certainly enhanced and a greater depth of understanding resulted.

P-CAD: A user's experience

P Chapman, Cornwall College

P-CAD is a professional level software package for schematic capture and PCB design. It is a complex package and takes some time to become familiar with. Once learnt, the system has great benefits relating to documentation and the production of PCB artwork. The adoption of a professional level package also attracted considerable interest from industry in short course provision.

Computer aids for electrical contracting

D Strentfield, Brunel Technical College

Existing software packages for the support of electrical contracting design and costing are relatively expensive. An in-house program was described and the relevant features discussed. While not as comprehensive as commercial packages, its user friendliness and simplicity were appreciated by the students and it served as an excellent introduction to CAD techniques.

The case for and against the semi-custom approach

S Medhat, Dorset Institute

The arguments for and against the semi-custom approach were examined in the context of what industry must do, and thus how we in education can best support them in providing training in new techniques. The path from discrete logic, through programmable logic devices, to gate arrays and standards cells was examined and the possible resources implications considered.

Impact of CAD on curriculum and training requirements

J Roach, Dorset Institute

Education must address the question of solving real-life engineering problems and there should be a continuous updating process for engineers. For UK industry to be competitive, ECAD must be taken up, and educationists must equip our future engineers appropriately. An examination of which courses require the inclusion of ECAD, together with some implications, were discussed:

- syllabuses tend to be too extensive;
- more emphasis needed on assignment-type work – less on regurgitation;
- more case studies – engineering as it is practiced;
- more industry/academic partnerships – ensure courses are up to date and provide industry with what it needs, while ensuring students obtain a portable qualification of a recognised standard;
- time is needed for training and generation of teaching material.

Thus, problems are:

- TIME – to master new techniques and generate teaching material;
- MONEY – hardware and software are expensive;
- INVOLVEMENT – all staff should be involved; this requires a continuous updating process.

Using CAD for hybrid circuit design

E Jefferson, Dorset Institute

The design of hybrid thick and thin film circuits is aided considerably using a modified 2D drafting package. Student project work involves the design of the hybrid circuit on the computer, fabricating the design and testing. Student interest is high and the whole process is a model of industrial practice which brings relevance to the teaching.

The management dilemma

J Jarvis, Swindon College

The balance between income and expenditure is a management problem and the introduction of CAD into the curriculum poses some important financial and personnel problems. Which software? Which hardware platform? An examination of choices was given with an important emphasis on the decision to choose a workstation or a PC. The problem was to identify the market. In some cases a mixed economy is appropriate, with some basic machines and software and a small number of high-powered machines with complex and sophisticated software. The question of maintenance and keeping up to date was also addressed.

Using AMX

P Sharpe, Chippenham Technical College

This presentation outlined a philosophy or approach to practical work, using AMX as one particular example. The laboratory described moved a long way towards the future electronics laboratory postulated earlier. Each student had a workstation, with the computer acting as documentation producer, circuit simulator and virtual instrument, in a novel and imaginative way. Student reaction was found to be extremely favourable, with demand for usage outstripping time available. The problems encountered were increased demands on staff time in the preparation of material and familiarisation with equipment.

The Mid-Kent experience

E Tottman, Mid-Kent College of Higher and Further Education

The collapse of the traditional local employee base caused great hardship but provided the impetus to redesign the course structure and gain funds for re-equipping to meet the challenge of CAD in Electrical and Mechanical Engineering. The establishment of an Advanced Technology Department was described, incorporating mechanical, electrical and plant engineering. This resulted in the developing of new areas of expertise and capitalising on them for local industry's benefit.

AMAZE: A user's experience

D Davies, Dorset Institute

AMAZE is a general purpose package run on IBM PC or compatible, which enables the user to design logic circuits using programmable logic devices. A demonstration of the program using a typical student's design was given. Logic circuit representation minimisation and generation of the fuse map were all covered, together with generation of a file for transfer to a programmer so that the device could be programmed.

PCB design

J Reynolds, Dorset Institute

A low-cost introductory program for PCB design was demonstrated and a user's experience given, outlining some of the drawbacks and limitations.

Conclusions and recommendations from the conference

The following points were put forward:

- Further and higher education must adopt CAD in all relevant courses as soon as possible.
- Further and higher education must follow industry in the introduction of CAD direction, but at times it may need to be proactive and act as a stimulus for the development of industrial systems.
- Benefits derived include increased student interest and motivation; it is an ideal vehicle for integrative assignments using a design–build–test cycle.
- There are significant resource and training consequences.
- An ECAD laboratory and centre for advice providing demonstrations and generation of appropriate teaching material and training courses could facilitate the regular exchange of views and experiences.

Hardware demonstrations were organised during the conference workshops.

Visits

An important aim of the project was to make contact with other colleges and get a feel for what was going on in the region. This was met by the conference which, through formal sessions and informal discussions, gave an opportunity to discover what colleagues were doing and the software and hardware in use, and to obtain information on a range of experiences. Seventeen of the 43 colleges originally contacted attended the conference. A number of other colleges were visited to see the resources available. The following colleges were visited by members of the project team:

- Bournemouth and Poole College of Further Education
- Swindon College
- Highbury College of Technology (Portsmouth)
- Brunel Technical College
- Filton Technical College
- Yeovil College
- Somerset College of Arts and Technology

Invitations which the project team were unable to accept came from:

- representatives from Sandwell College of Further and Higher Education
- the Open University
- Exeter College
- Basingstoke Technical College

In addition, various telephone conversations provided information.

Recommendations

As shown by the survey and conference, there was much interest in CAD for electronics/electrical

engineering. This activity appears to be uncoordinated, with no overall aim or plan. There is a general feeling that CAD is a 'good' thing and colleges ought to be involved in it.

A firm direction is needed, and an overall strategy should be established so that good practice is disseminated as widely as possible. From the experience in carrying out the survey, running the conference, visiting colleges and using CAD in teaching, the author can make the following recommendations.

General recommendations

- CAD techniques must be adopted in relevant courses as soon as possible.
- A practical, hands-on approach following introductory instruction is favoured, with some guided tutorial material.
- CAD can be used as a vehicle for integrative assignments.
- Time must be made available for staff development and training/updating.

Specific recommendations

- To alleviate the high cost of software, particularly where class sets are required, appropriate software products should be identified and purchased in bulk, and multiple site licences obtained for all FHE colleges. The model used could be the UGC/PolyCAD initiative for CAD software for ASIC design.
- National and regional advice centres should be established to provide support for the production of ECAD hardware/ software, training courses for staff, and a peripatetic support officer who could liaise with colleges and offer in-house courses and support.
- Courses or individual units of study should be selected and course material generated based on a CAD approach using widely available software/hardware.
- A program of regular awareness seminars should be initiated to keep colleagues aware of activity in this field of study.

Grants from central agencies, together with industrial support from hardware and software vendors, could also be sought in support of the above recommendations.

Implications

There should be adequate staff time to permit training and staff development. Shortage of suitable hardware and software could be addressed by a national initiative, and a 'notional' saving could take place if a bulk purchase of both hardware and software was introduced. This national initiative could be supported by regional centres to provide staff support and generate teaching material. This could include tutorial support and generation of self-learning packages suitable for open learning. Regional support centres could be based in existing colleges and would need at least one CAD support engineer and secretarial assistant. In time, these would provide a bank of knowledge and expertise to be available for continuing development in colleges.

Summary

The survey, conference and visits carried out by the project team have clearly indicated a need for a development plan for the introduction of ECAD into further and higher education courses. The problem of familiarisation time and availability of appropriate software, together with the time taken to generate good teaching support material, have been noted and possible solutions outlined.

Some general and specific recommendations have been given which should be considered carefully. This project has proved valuable both as an information gathering exercise and in highlighting some potential problems which could have a deleterious effect on the efficiency and viability of the UK electronics industry

Further information on the background to the project can be obtained from Albert Clyde at the FEU (tel. 01-321 0433 ext 236). Those interested in the technical issues raised should contact Sa'ad Medhat at Dorset Institute of Higher Education, Norwich Union House, Christchurch Road, Bournemouth, Dorset BH1 3NG. (Tel. 0202 524111).

ISBN 1 85338 152 7

Printed by The Chameleon Press Limited, 5–25 Burr Road, London SW18 4SG